REMARKS

The specification is amended to correct a spelling error and to more clearly describe the invention. No new matter is added by this amendment. Applicants amend claims 1, 6, 29, and 34. Claims 5 and 33 are cancelled without prejudice to their underlying subject matter. The subject matter of the cancelled claims has been incorporated into the respective depending claims. Attached hereto is a marked-up version of the changes made to the specification and claims by the amendment.

Submitted concurrently herewith are Proposed Drawing Corrections wherein new FIGs. 4-7 are submitted for approval. FIGs. 4 and 7 are corrected to have acceptable margins, FIGs. 5 and 7 are corrected to have plain and legible numbers and reference characters, and FIG. 6 is corrected to substitute the reference number 22, indicating the polymer etch residue, for 29, which does not refer to anything in the description. This was a clerical error. The proposed changes are in red ink and substitute formal drawings are enclosed.

Claims 1 and 2 stand rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. patent number 6,242,165 (Vaartstra). Applicants respectfully traverse this rejection.

Claim 1, as amended, defines a method for removing polymer etch residue from an etched opening in a silicon wafer device, and recites "forming an opening in an insulating layer, wherein a polymer etch residue remains within said opening after the opening forming step" and "contacting said opening with a plasma generated from ammonia gas to remove said polymer etch residue." Vaartstra does not anticipate this claimed method.

Vaartstra discloses use of supercritical fluids to treat organic material residue on surfaces of an object (such as a semiconductor device). Vaartstra defines a supercritical fluid as "[a] gas . . . subjected to a combination of pressure and temperature so that its density approaches that of a liquid (i.e., the liquid and gas state coexist)." (column 2, lines

29-33). Vaartstra discloses that use of a supercritical fluid offers a replacement for conventional etching techniques (i.e., wet and dry etching), which, according to Vaartstra, fail to offer satisfactory results. Vaartstra states, "[w]et removal generally refers to the contact of a surface with a liquid chemical solution," and "[d]ry etching refers to the contact of a surface with a gaseous plasma composition" (but nowhere refers to use of an ammonia plasma). (column 1, lines 28-31).

Vaartstra goes on to state, "[b]oth wet and dry organic removal techniques may not provide adequate removal when organic materials are present in complex structures, such as high aspect ratio openings." (column 1, lines 62-65). These statements in Vaartstra are evidence that Vaartstra does not teach or suggest (and is actually teaching away from) use of an ammonia plasma for removing polymer etch residue, particularly within a high aspect ratio opening. To the contrary, Vaartstra discloses a process to be used in lieu of a plasma treatment (as recited in the claims), or wet etch procedure. The procedure of Vaartstra is only disclosed to be use of "[s]upercritical compositions for removal of organic material" (column 4, lines 25-28) and further, Vaartstra's only disclosure of any ammonia composition is as a supercritical fluid component (column 5, line 54), not as a plasma. Thus, Vaartstra does not anticipate claims 1 and 2.

Since Vaartstra does not anticipate claim 1 and claim 2 depending therefrom, claims 1 and 2 are patentable thereover. Applicants respectfully request that the 35 U.S.C. § 102(e) rejection of claims 1 and 2 be withdrawn.

Claims 1-15, 25, and 26 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Hopper et al. Applicants respectfully traverse this rejection.

In considering any patent as a reference for 35 U.S.C. § 103 purposes, it must be considered as a whole, including any teaching away, and further, it must suggest the desirability and obviousness of combining it with the other references. M.P.E.P. §§ 2141.01 and 2141.02 (2001) (emphasis added). In accordance with M.P.E.P. § 2144.05.III, a prima facie case of obviousness is rebutted by showing that a reference, in

any material respect, teaches away from the claimed invention. M.P.E.P. § 2144.05.III (2001) (emphasis added), citing In re Geisler, 116 F.3d 1465, 1471, 43 U.S.P.Q.2d 1362, 1366 (Fed. Cir. 1997). "A prior art reference that 'teaches away' from the claimed invention is a significant factor to be considered in determining obvious." M.P.E.P. § 2145.X.*D*.1 (2001). "References cannot be combined where [a] reference teaches away from their combination" for the purposes of supporting a rejection under 35 U.S.C. § 103(a). Id. at X.*D*.2. Hopper et al. does not teach or suggest the claimed method and, in fact, teaches away from the claimed method and is, therefore, an improper reference for use in rejecting the claims under 35 U.S.C. § 103(a).

Hopper et al. does not teach or suggest the method of claim 1. Hopper et al. is directed to a process of photoresist stripping so as not to increase the dielectric constant of an exposed carbon-containing dielectric material (i.e., a polymeric layer). (Abstract; column 2, lines 49-50). The process of Hopper et al. involves a different step in semiconductor processing from the claimed "removing polymer etch residue" step. The Hopper et al. process begins and ends at the removal of a photoresist used to mask a carbon-containing dielectric layer, which can itself be a polymer. (column 4, lines 43-49).

Additionally, Hopper et al. teaches away from the claimed method because the stated goal of Hopper et al. is to not effect the carbon-containing dielectric material, which can be a polymer layer, upon etching to remove the photoresist thereover. (column 3, lines 40-43; column 4, lines 43-49; column 5, lines 13-17). Hopper et al. specifically states that this process of not effecting (i.e., effecting by increasing the dielectric constant or removing) the dielectric (i.e., polymer) "is applicable to a wide variety of low dielectric constant carbon-containing materials . . . include[ing] various polymers." (column 5, lines 13-17 and 61-62). Hopper et al. indicates that its process does not have any impact on polymers. In contrast, the claimed method is directed to removing a polymer etch residue with a plasma etching step; directly inapposite to the disclosed process of Hopper et al. Since the Hopper et al. process is disclosed as not effecting polymers, the claimed method is not taught or suggested by Hopper et al. In this regard, Hopper et al. teaches away from

the claimed invention, rendering Hopper et al. an improper reference for rejecting the claims.

Additionally, Hopper et al. does not teach or suggest using "a plasma generated from ammonia gas" to remove polymer etch residue. The Office Action, at page 3, ¶ 5, "interprets that the combined nitrogen and hydrogen gas plasma is equivalent to ammonia gas plasma because they contain the same species." This is an incorrect interpretation, particularly in view of the disclosure in Hopper et al. of the ratio of hydrogen to nitrogen gases utilized by its process. Unlike the recited ammonia, which has a chemical formula of NH_3 and, therefore, a stoichiometric ratio of three hydrogen atoms to 1 nitrogen atom, the plasma disclosed by Hopper et al. contains "about 1 to about 10 vol. % of hydrogen . . . and about 99 to about 90 vol. % nitrogen," meaning that Hopper et al. discloses a hydrogen to nitrogen ratio of about 1:9. The gas mixture of Hopper et al. described as including hydrogen and nitrogen is NOT ammonia, which is an entirely different chemical with entirely different chemical and physical properties from elemental hydrogen and nitrogen. Further, as illustrated above, even if one were to compare the base elements of the recited ammonia to the free hydrogen and nitrogen of Hopper et al., it is clear that there are vastly different proportions of these elements present in the claimed plasma and the reference's plasma. Thus, free hydrogen and free nitrogen is not the same as or equivalent to gaseous ammonia and Hopper et al. does not teach or suggest the recited "plasma generated from ammonia gas" as claimed.

Claims 25 and 26 depend from claim 16, which defines a method for removing polymer etch residue from an etched opening in a silicon wafer device and recites "contacting said opening with an oxygen containing plasma, stopping said oxygen plasma contacting before said polymer etch residue is completely removed and thereafter contacting said opening with ammonia gas." These steps are not taught or suggested by Hopper et al.

For similar reasoning as set forth above regarding the patentability of claim 1 over Hopper et al., likewise the method of claim 16 is not taught or suggested by Hopper

et al. As noted above, Hopper et al. does not teach or suggest using an ammonia gas for the removal of a polymer etch residue, but teaches a ratio of free hydrogen and nitrogen gas that is not comparable to ammonia. Additionally, Hopper et al. teaches away from the recited "contacting said opening with an oxygen containing plasma," since the stated goal of Hopper et al. is to achieve a plasma chemistry weaker than O_2." (column 3, line 5). And further, as discussed above, Hopper et al. also teaches away from removing polymer etch residue, as claimed, since the process of Hopper et al. is specifically designed not to lower the dielectric constant or remove the potentially-polymeric insulating layer (ILD). As depending from claim 16, claims 25 and 26 are likewise not taught or suggested and are, in fact, taught away from by Hopper et al.

Since the Hopper et al. reference does not teach or suggest the method of claim 1 or claim 16, and actually teaches away from the methods claimed, these claims and respective depending claims 2-15 and 25-26 are patentable over Hopper et al. Applicants respectfully request that the 35 U.S.C. § 103(a) rejection of claims 1-15, 25, and 26 be withdrawn.

Claims 16-24, 27, and 28 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. patent number 6,284,664 (Kawai) in view of Hopper et al. Applicants respectfully traverse this rejection.

For at least the same reasoning above regarding the patentability of claim 16 (and depending claims 25 and 26), Hopper et al. would not have rendered its subject matter obvious. The disclosure of Kawai cannot supplement the inadequacies of Hopper et al. in this regard, even if Hopper et al. did not teach away from their combination. But, Hopper et al. and Kawai are not combinable references since Hopper et al. specifically teaches away from their combination. Hopper et al. specifically notes that its goal is to do away with use of an oxygen containing plasma since such will tend to lower the dielectric constant of and strip a portion of an ILD layer. To achieve this goal, Hopper et al. discloses the use of a hydrogen and nitrogen substitute etchant. Therefore, the very method Kawai is cited for would not have been added to the process of Hopper et al.

Since Hopper et al. and Kawai cannot properly be combined, and even if they could, would not have rendered the subject matter of claim 16 obvious, claim 16 and depending claims 17-24, 27, and 28 are patentable thereover. Applicants respectfully request that the rejection of claims 16-24, 27, and 28 under 35 U.S.C. § 103(a) be withdrawn.

Claims 29 and 41-44 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Kawai in view of Vaartstra. Applicants respectfully traverse this rejection.

Claim 29, as amended, defines a method of forming a contact opening in a semiconductor device and recites, in part "cleaning etch residue from said etched opening by contacting said opening with ammonia gas in the form of a plasma." The combination of Kawai and Vaartstra does not teach or suggest this method.

Neither Kawai, nor Vaartstra teach or suggest use of an ammonia gas plasma. Vaartstra does not teach or suggest the claimed method for at least the same reasoning set forth above regarding the patentability of claim 1. Kawai discloses removal of an organic layer in a contact hole using a plasma mixture of CF_4 and O_2, and does not teach or suggest that any other plasma types can be substituted for this mixture. Kawai does not mention ammonia as useful in any cleaning step, particularly as a plasma for removing the organic layer. Since neither Kawai nor Vaartstra, taken individually or in combination teach or suggest the subject matter of claim 29, claim 29 and claims 41-44 depending therefrom are patentable over the combination of Kawai and Vaartstra. Applicants respectfully request that the 35 U.S.C. § 103(a) rejection of claims 29 and 41-44 be withdrawn.

Claims 30-38 and 40 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Kawai in view of Vaartstra, as applied to claims 29 and 41-44, and further in view of Hopper et al. Applicants respectfully traverse this rejection.

As already discussed, Hopper et al. teaches away from combination with Kawai, and does not teach or suggest use of ammonia gas (or its equivalent). Additionally, none

of Vaartstra, Kawai, or Hopper et al. teach or suggest use of the recited "ammonia gas in the form of a plasma," so even if combined, these references do not teach or suggest the method claimed. Additionally, for the same reasoning set forth above regarding the patentability of claim 29, claims 30-38 and 40 depending therefrom are patentable over the combination of Kawai and Vaartstra. Further, even if Hopper et al. did not teach away from combination with these other references (which it clearly does), Hopper et al. does not disclose anything to remedy the inadequate disclosures of Kawai and Vaartstra so as to have rendered the subject matter of claim 29 or those claims depending therefrom obvious. Applicants respectfully request that the 35 U.S.C. § 103(a) rejection of claims 30-38 and 40 be withdrawn.

Claim 39 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Kawai in view of Vaartstra and U.S. patent number 6,291,890 (Hamada). Applicants respectfully traverse this rejection. Claim 39 should be allowable along with claim 29 and for other reasons.

Claims 50-53 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Kawai in view of Hopper et al. and Hamada. Applicants respectfully traverse this rejection.

The Office Action at pages 7-8 notes that the combined teachings of the references "does not expressly disclose the etching of the polymer residue using oxygen prior to ammonia." The Office Action's explanation that this would have been obvious because oxygen plasma is a commonly used etchant and a plasma of hydrogen and nitrogen gases can remove residue more efficiently is not sufficient to make a prima facie case. The statement does not establish that using "oxygen prior to using said gas which provides an oxide free bottom of said contact opening" as recited in claim 52 would have been an obvious combination over the prior art. As discussed above, Hopper et al. teaches away from any combination with a reference disclosing a process using an oxygen plasma, so this combination is improper. Also, the step of "using a gas which provides an oxide free bottom of said contact opening" is not taught or suggested by any combination of Kawai

and Hamada, with or without Hopper et al. Kawai requires use of oxygen in the etchant gas, which would not enable the providing of "an oxide free bottom of said contact opening" as recited if the process of Kawai were followed.

Because Hopper et al. is not properly combined with Kawai and Hamada, Kawai teaches away from the claimed method, and even if combined, these references would not have rendered the subject matter of claims 50-53 obvious, claims 50-53 are patentable over these references taken individually or in combination. Applicants respectfully request that the 35 U.S.C. § 103(a) rejection of claims 50-53 be withdrawn.

In view of the above, each of the presently pending claims in this application is believed to be in immediate condition for allowance. Accordingly, the Examiner is respectfully requested to withdraw the outstanding rejection of the claims and to pass this application to issue.

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Respectfully submitted,

By MJT #33,082

Mark J. Thronson
Registration No.: 33,082
Ryan H. Flax
Registration No.: 48,141
DICKSTEIN SHAPIRO MORIN & OSHINSKY LLP
2101 L Street NW
Washington, DC 20037-1526
(202) 785-9700
Attorneys for Applicants

Version With Markings to Show Changes Made

In the Specification:

At page 14, second full paragraph (line 10 to line 20), please replace with the following.

Titanium deposition in the contact opening 20 can be done in a manner known in the art. For example, titanium is deposited on the wafer using a sputter process commonly used with metals. A target containing titanium is surrounded by an argon plasma. Ions from the plasma hit the target surface. The titanium atoms which are removed from the metal target then coat the wafer surface. It is also possible to utilize CVD techniques in which the titanium is formed from the reaction of $TiCl_4$ with hydrogen (H_2). In any [even] event, [it is very important that] the deposition material should get down into the High Aspect Ratio opening, and reach the bottom surface of the opening or via 20. A collimator may be used to direct the atoms straight down, for better coverage on the contacts.

In the Claims:

1. (Amended) A method for removing polymer etch residue from an etched opening in a silicon wafer device, comprising:

forming an opening in an insulating layer, wherein a polymer etch residue remains within said opening after the opening forming step; and

contacting said opening with a plasma generated from ammonia gas to remove said polymer etch residue.

5. CANCELLED

6. (Amended) The method of claim [5] 2, wherein said contacting is done at a temperature within the range of about 250 - 500° C.

29. (Amended) A method of forming a contact opening in a semiconductor device, comprising:

a) etching a contact opening in an insulative layer in said device down to a polysilicon element of said device; and

b) cleaning etch residue from said etched opening by contacting said opening with ammonia gas in the form of a plasma.

33. CANCELLED

34. (Amended) The method of claim [33] 30, wherein said contacting is done in a plasma reactor at a temperature within the range of about 250 - 500° C, with a reactor power within the range of about 500 – 2500 watts, with an ammonia gas flow rate of about 500 to 1000 SCCM, and for a period of no more than 100 seconds.

MARK-UP VERSION

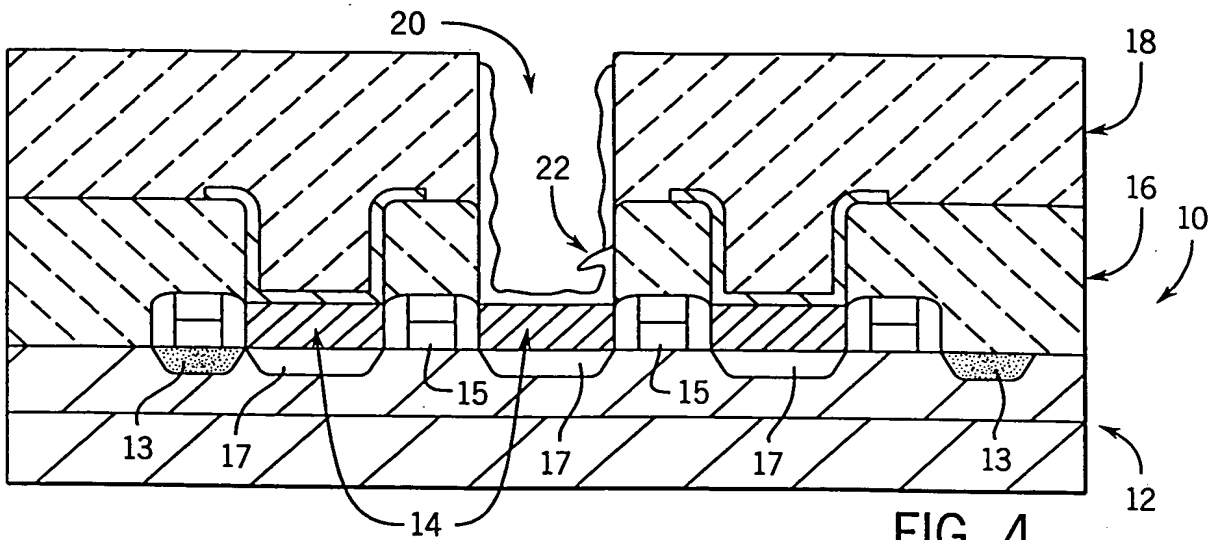

FIG. 4

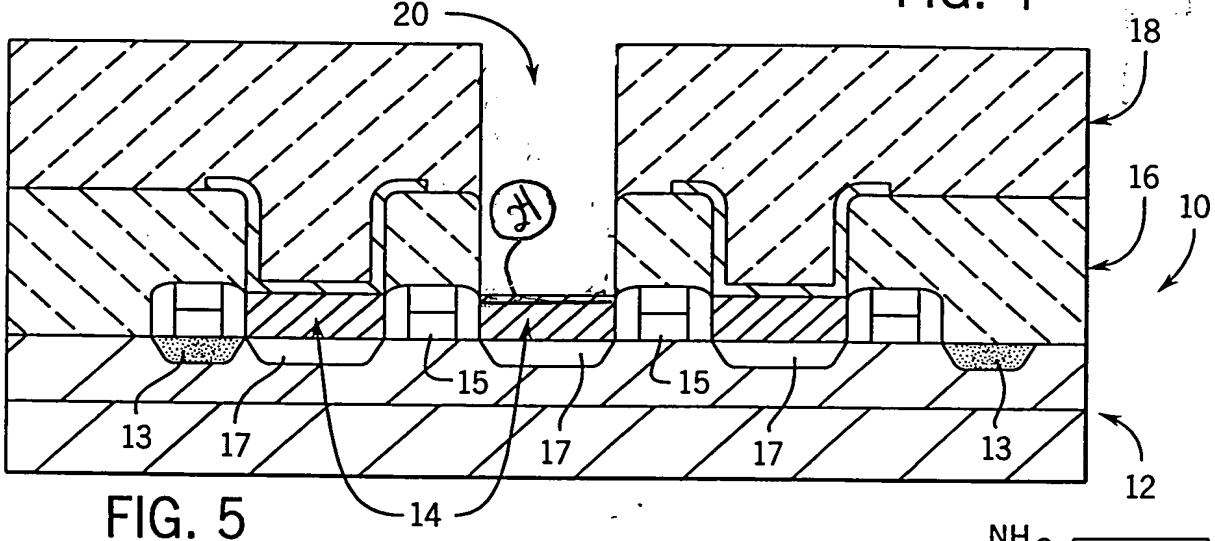

FIG. 5

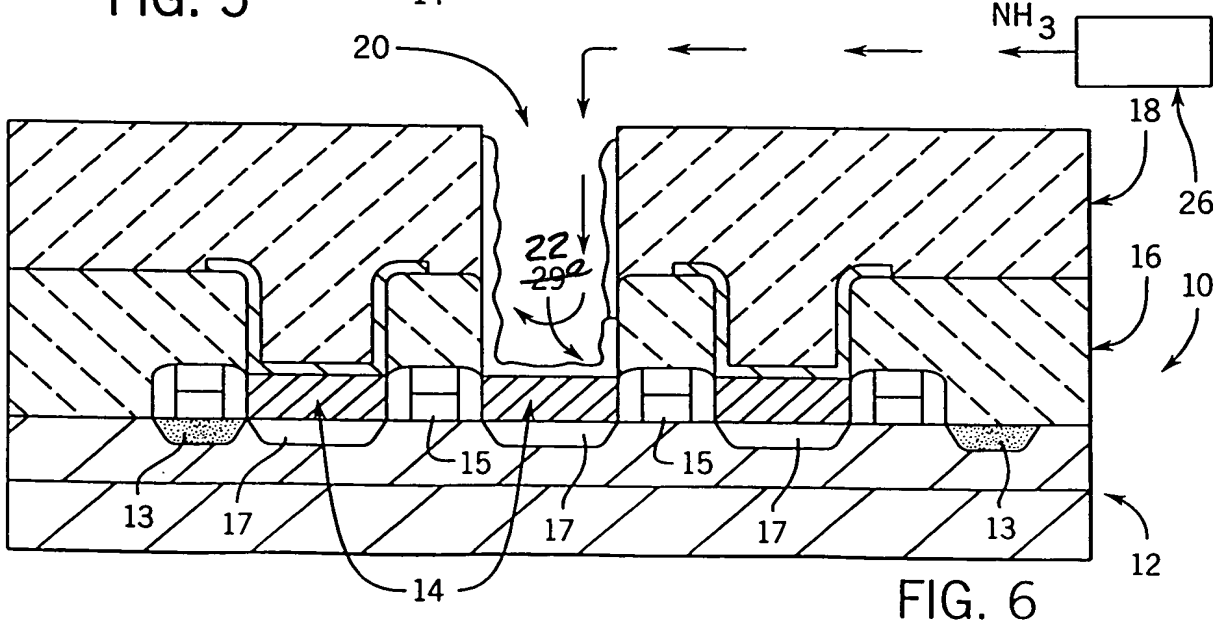

FIG. 6

MARK-UP VERSION

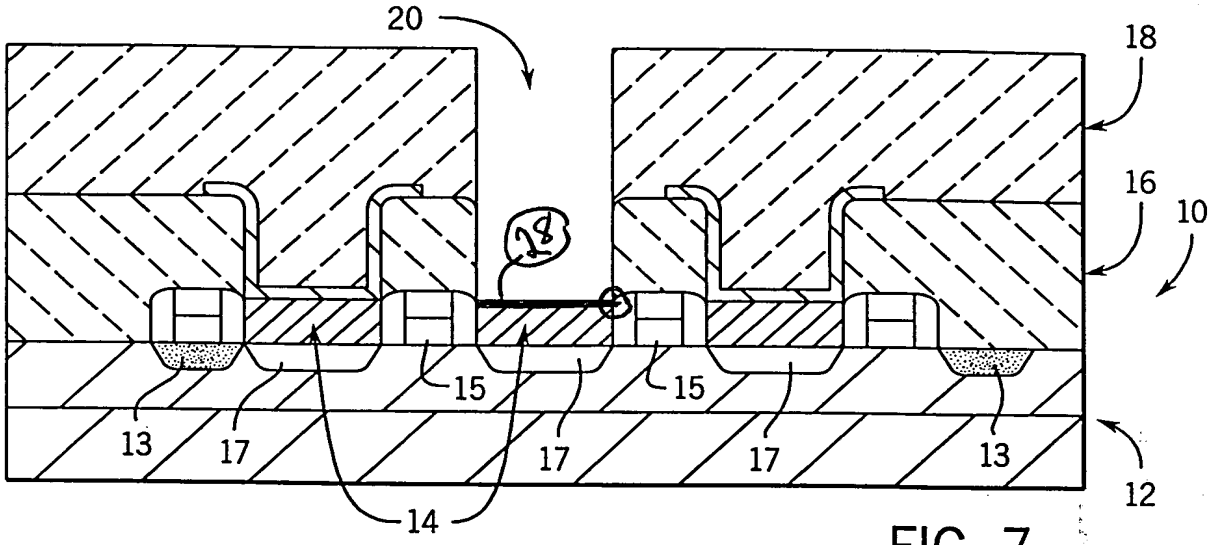

FIG. 7

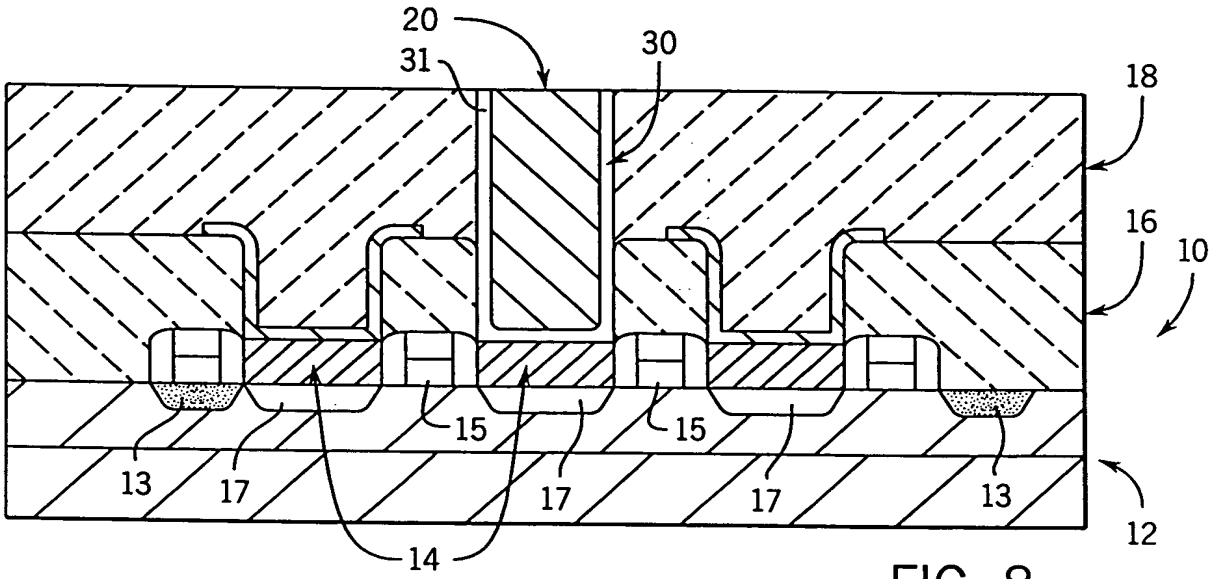

FIG. 8